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Final Report

Adapted Waveform Analysis for ATD/R

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ABSTRACT. This research aims at improving most steps involved in the ATD/R process, starting with preprocessing, including denoising, segmentation, background and clutter removal and followed by feature extraction and definition to enhance the classification and recognition process. These steps are directly tied to fast numerical algorithms whose purpose is to enable real time ATD/R. The toolkit developed in this project is currently being successfully used by Martin Marietta to enhance their Radar return ATR and by Hughes Research Labs for Fast Radar return simulations.

1. Objectives

The purpose of the project was to explore and develop an Adapted Waveform Analysis toolkit for ameliorating the processing steps involved in ATR, either by accelerating the computation or by providing new means of analysis and modeling, as well as for extracting features and classification.

AWA extends Fourier analysis to a broader collection of waveforms (with better time frequency localizations), where the choice of waveforms for analysis (or appropriate orthonormal basis) is made automatically by a measure of fit between the class of targets and the corresponding waveforms.

These methods have already been successfully tested on Radar data, and need to be modified and adapted to other classes of sensors. The waveform used in adapted waveform analysis consist (in the high frequency case) of various libraries of orthonormal bases of localized trigonometric polynomials, or specific exponential sums (as arising in the Fast Multipole method for Helmholtz equation). And in the

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low frequency case of libraries and wavelets and wavelet-packets, again corresponding to multipoles for Laplaces equation.

2. Results

The methodology for automatic feature extraction for classification and regression developed by Coifman and Saito has been incorporated into an ATR Diagnostic toolkit enabling interactive data based adaptation of the features to the classifier environment, this is currently being tested and used by various teams including the Lockheed Martin Radar group.

Fast algorithms for electromagnetic waveform compression and for scattering simulations have been substantially improved. New libraries of orthonormal bases with directional frequency sensitivity (brushlets) have been invented for processing SAR data, as well as for texture discrimination.

3. Accomplishments

We have developed a toolkit for AUTOMATIC diagnostic feature extraction, in which the feature selected for classification are optimized for optimal separation and parameter estimation. These methods have been applied and validated on Radar returns from Lockheed Martin, as well as on a variety of other sensor data.

Methods for automatic feature selection and definition have been developed.

A toolkit for Image denoising and enhancement was developed in which the image is modeled by a rudimentary musical transcription, permitting a rough model of noise and clutter and providing separation. These methods have been applied and validated on audio, images and video allowing for separation of image from speckle in SAR data and substantial enhancement of NMR videos. Our feature selection toolkit has been successfully validated by a Martin Marietta team for Radar returns ATR.

Our algorithms for fast computation of Electromagnetic Scattering have demonstrated their capability in breaking the EM logjam, they have been converted into engineering code by Hughes Research Lab, as well as by Boeing Corp.

4. Personnel supported

R. Coifman, V. Rokhlin, PI's

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L. Woog, S. Kapur, N. Yarvin, R. Guglielmi, T. Hrycak, M. Mohlenkamp, N. Bennett, N. Saito, Graduate Students

5. Technical Publications

Journal Publications R. Coifman:

1. (with N. Saito) "Local discriminant bases and their applications". Journal of Mathematical Images and Vision 5, 1995.

2. (with Y. Meyer) "Gaussian Bases". Applied and Computational Harmonic Analysis 2, 1995.

3. (with I. Popovic, J. Berger) "Towards a unified representation of sound and analytical structure in music. Preprint.

4. (with Averbuch, Beylkin, Israeli) "Multiresolution solution of elliptic and parabolic PDE, 1995.

5. (with Qu'yen Huinh, Walter Greene) "Feature extraction and classification of marine biological species."

6. (with Yves Meyer, G. Matviyenko) "Wigner distributions and related atomic decompositions." To appear ACHA 1995-6.

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